Membrane System for Recovery of Volatile Organic Compounds from Remediation Off-Gases

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Abstract

In situ vacuum extraction, air or steam sparging, and vitrification are widely used methods of remediating soil contaminated with volatile organic compounds (VOCs). All of these processes produce a VOC-laden air stream from which the VOC must be removed before the air can be discharged or recycled to the generating process. Treatment of these off-gases is often a major portion of the cost of the remediation project. Carbon adsorption and catalytic incineration, the most common methods of treating these gas streams, suffer from significant drawbacks.

Membrane Technology and Research, Inc. (MTR) proposes an alternative treatment technology based on permselective membranes that separate the organic components from the gas stream, producing a VOC-free air stream. The technology we propose to develop can be applied to all of these off-gas streams and is not tied to a particular off-gas generating source. We propose to develop a completely self-contained system because remediation projects are frequently in remote locations where access to trained operators and utilities is limited. The system will be a turnkey unit, skid-mounted and completely automatic, requiring power but no other utilities. The system will process the off-gas, producing a concentrated liquid VOC stream and a purified gas containing less than 10 ppm VOC that can be discharged or recycled to the gas-generating process.

Removal of VOCs from air streams with membranes is a relatively new technology. To date, most membrane systems have been installed on process streams in the refining and petrochemical industries. The first demonstration plants were installed by MTR in 1990-91, with the first commercial plants being sold in 1992-93. Currently, more than 30 units are operating in the United States, all supplied by MTR. Off-gases produced in DOE remediation operations are much less concentrated in VOCs than the chemical plant streams treated by our membrane technology to date. A pilot test of a membrane system at the Hanford Nuclear

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Reservation on an off-gas stream containing 200-1,000 ppm carbon tetrachloride showed the overall feasibility of the process. The membrane system consistently achieved greater than 95% VOC removal and produced dischargeable air containing less than 20 ppm VOC. The test also showed that modifications to the system design are required to tailor the technology to this application. In particular, the module design must be modified to improve the VOC/air separation. Also, the system design must be changed to allow operation with flammable VOCs and to remove water coextracted with the VOCs, to reduce the volume of hazardous waste requiring disposal.

MTR will undertake a two-phase, twenty-four month program to develop a system that will meet DOE's needs for off-gas treatment. The first six-month laboratory phase covers the demonstration of the water separation section of the unit, production and demonstration of new membrane modules to improve the separation, and the design studies required for the demonstration system. A preliminary cost and competitiveness analysis will be prepared as part of the design study and potential field sites will be evaluated in preparation for the Phase II evaluation process. In the second 18-month phase, the demonstration system will be built and, after a short laboratory evaluation, will be tested at two field sites with widely differing VOC-containing streams. The first site would be a soil vacuum extraction or steam sparging operation because this is likely to be a major application of our technology. Ideally, the second site would provide a more complex stream possibly containing flammable VOCs and other contaminants at high VOC concentrations. In situ soil vitrification operations produce this type of off-gas.

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